REMARKS

The above amendments to the above-captioned application along with the following remarks are being submitted as a full and complete response to the Official Action dated July 8, 2004 and the phone interview with the Examiner on July 2, 2004. Applicants thank the Examiner for taking the time to consider the informal response. The Examiner indicated that the application appeared to be allowable, and suggested filing the response to be formally considered.

In view of the above amendments and the following remarks, the Examiner is respectfully requested to give due reconsideration to this application, to indicate the allowability of the claims, and to pass this case to issue.

Status of the Claims

Claims 1, 5-7, 9-11, 15-17 and 19-20 are under consideration in this application. Claims 2-4 and 12-14 are being canceled without prejudice or disclaimer. Claims 1, 10-11, and 20 are being amended, as set forth in the above marked-up presentation of the claim amendments, in order to more particularly define and distinctly claim applicants' invention.

Additional Amendments

The claims are being amended to correct formal errors and/or to better disclose or describe the features of the present invention as claimed. All the amendments to the claims are supported by the specification. Applicants hereby submit that no new matter is being introduced into the application through the submission of this response.

Prior Art Rejections

Claims 1-5 and 11-15 were rejected under 35 U.S.C. § 102(b) on the grounds of being anticipated by U.S. Pat. No. 5,953,357 to Hirata et al. (hereinafter "Hirata"), and claims 1-7, 9-17 and 19-20 were further rejected under 35 U.S.C. § 102(e) on the grounds of being anticipated by U.S. Pat. No. 6,219,366 to Furushima (hereinafter "Furushima"). These rejections have been carefully considered, but are most respectfully traversed.

The semiconductor laser according to the invention, as now recited in claim 1, comprises: a semiconductor substrate 101; a core region defined by an active layer 105 (or further including layers 104, 106) formed on one side of the semiconductor substrate 101; and a clad region defined by at least one clad layer 107, 108 overlaying the active layer 105. The core region has

a *gain region* (i.e., an active region) with a length not smaller than **18** micrometers and not greater than 200 μm (e.g., 100 μm long in Fig. 1) along an optical axis of at least the core region or the clad region; at least one of the core region and the clad region has a stripe shape and a stripe width modulated in a direction parallel with a surface of the substrate and perpendicular to the optical axis such that the center portion of the stripe, which works as a multi-mode interference waveguide (e.g., 75 μm long, 6 μm wide in Fig. 1; page 6, line 25) enabling a lateral multimode, has a wider width than vicinity portions of the stripe, each of which works as a mono-mode waveguide (e.g., 12.5 μm long, 1.6 μm wide in Fig. 1). The multi-mode interference waveguide has a rectangular plane shape with a lateral width W and a waveguide length L which are decided so that a light intensity distribution at an output terminal of said multi-mode interference waveguide becomes a single-hill lowest order mode(p. 3, lines 23-24). Further, W, L, an effective refractive index n of a laser waveguide, and an operation wavelength λ are decided so as to satisfy a formula as follows: $0.9nW^2/\lambda \leq L \leq 1.1n\ W^2/\lambda$.

In Fig. 1, the core region is a multi-quantum well active layer 105. The active layer is a region in which a gain is attained, and so the active layer 105 is a gain region. As in Fig. 1, the gain region of the core region includes both the multi-mode interference waveguide and the mono-made waveguides such the gain region includes the 75 μm long multi-mode interference waveguide and two 12.5 μm long mono-mode waveguide such that it's total length is 100 μm long.

The major purpose of the present invention is to provide the length of a gain region in a semi-conductor laser resonator of not greater than 200 μm without reducing current injection area or increasing a serial resistance. In order to avoid increasing the serial resistance, the present invention includes a multi-mode interference waveguide whose light intensity distribution at an output terminal thereof becomes a single-hill lowest order mode. According to the present invention, even if a light in the multi-mode interference waveguide has multi-modes, the lateral width W and the wavelength L thereof are so decided that a light at the output thereof shows a mono-mode. Accordingly, the mono-mode light appears at the output of the multi-mode interference waveguide, and progresses to the mono-mode waveguide connected thereto. Consequently, a signal light having a mono-mode at the output of the laser progresses into an optical fiber.

In other words, by including the multi-mode interference waveguide as a part of the gain region, the gain region plain area is increased than the prior art such that an element resistance

is reduced. Further more, the length of the gain region of the resonator is reduced such that a threshold value current is reduced and a mitigation oscillation frequency is increased. According to the present invention, a mono-mode waveguide is directly connected to a rectangular multi-mode interference waveguide. Therefore, a total length of the laser resonator comprising both the rectangular multi-mode interference waveguide and the mono-mode waveguide can be easily reduced. By reducing the total length of the resonator, the number of elements contained in one wafer is increased thereby reducing the production cost.

The invention, as now recited in claim 11, is also directed to a semiconductor laser comprising: a semiconductor substrate; a core region defined by an active layer (page 6, line 15) formed on one side of the semiconductor substrate; and a clad region defined by at least one clad layer at least overlaying the active layer. The core region has a gain region with a length not smaller than **5** μm and not greater than 200 μm.

The invention as recited in claims 10 and 20, is further directed to an optical module comprising at least an optical fiber for introducing light outside and a semiconductor laser as recited in claim 1 or claim 11.

Applicants respectfully contend that none of the cited references teaches or suggests semiconductor laser having "a gain region (1) including a rectangular plane shaped multi-mode interference waveguide and mono-made waveguides (with a width narrower than the lateral width W of the multi-mode interference waveguide) and (2) being no greater than **200 μm** long, while the lateral width W and a waveguide length L of the multi-mode interference waveguide are decided so that a light intensity distribution at an output terminal of said multi-mode interference waveguide becomes a single-hill lowest order mode, and W, L, an effective refractive index n of a laser waveguide, and an operation wavelength λ are decided to satisfy a formula as follows: $0.9nW^2/\lambda \leqq L \leqq 1.1n\ W^2/\lambda$" as the invention.

In contrast, the gain region 3 in Hirata (Fig. 1), where a gain is attained, is provided under both a straight portion 7b and tapered portions 7a with a length L = L2 + 2 * L1 (Fig. 2) = **400μm** (col. 5, lines 5-8), rather than 200 μm as alleged by the Examiner. Further more, Hirata's L2 region 7b simply does not function as any multi-mode interference waveguide. Hirata only concerns reducing the drive voltage and increasing the horizontal radiation angle in the far field pattern, etc (col. 2, lines 55-59).

Even if, arguendo, the L2 regions 7b functions as a multi-mode interference waveguide, the tapered degree of the tapered portions 7a should be small in order to decrease a mode transfer

loss (e.g. a multi-mode --> a mono-mode) such that the length of the tapered portions 7a need to be sufficiently long. As a result, the total length of Hirata's laser resonator becomes longer than the invention. On the other hand, the invention adopted straight portions functioning as mono-made waveguides.

Furushima shares the same deficiencies as Hirata. The gain region in Furushima (Fig. 4B), where the active layer 9 is available such that a gain is attained, includes both a linear gain waveguide portion 17 (col. 7, lines 18-19), two tapered portions 5, and two facet straight portions 16 with a total length L at least **450 μm** (190 μm + 2 * 130 μm; col. 5, lines 58-61), rather than 200 μm as alleged by the Examiner. Further more, Furushima fails to teach or suggest the waveguide portion 17 functioning as any multi-mode interference waveguide. The tapered portions 5 also need to be sufficiently long such that the total length of Furushima's laser resonator becomes longer than the invention.

Applicants contend that neither Hirata, Furushima, nor their combination teaches or discloses each and every feature of the present invention as disclosed in independent claims 1, 10-11 and 20 As such, the present invention as now claimed is distinguishable and thereby allowable over the rejections raised in the Office Action. The withdrawal of the outstanding prior art rejections is in order, and is respectfully solicited.

Conclusion

In view of all the above, clear and distinct differences as discussed exist between the present invention as now claimed and the prior art reference upon which the rejections in the Office Action rely, Applicant respectfully contends that the prior art references cannot anticipate the present invention or render the present invention obvious. Rather, the present invention as a whole is distinguishable, and thereby allowable over the prior art.

Favorable reconsideration of this application is respectfully solicited. Should there be any outstanding issues requiring discussion that would further the prosecution and allowance of the

above-captioned application, the Examiner is invited to contact the Applicants' undersigned representative at the address and phone number indicated below.

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